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ADHESION BETWEEN ATOMICALLY PURE METALLIC SURFACES

PART IV

by

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INTRODUCTION

The July, 1967 semi-annual report consists of a paper presented to the International Vacuum Metallurgy Conference (New York City, June, 1967) reviewing the status of metallic adhesion and a Masters Degree thesis by W. Saunders on the solid state adhesion of tungsten-silver couples in ultra-high vacuum. (Detached)

As indicated in the last semi-annual report on the progress of adhesion research in this laboratory, a preliminary effort early this year was initiated to examine the effects of gaseous contaminants, particularly halides, on the junction strengths of silver-silver couples in adhesion. Although some progress had been made in this direction, certain advancements in ultra-high vacuum friction research at the NASA Lewis Laboratories, indicated that a knowledge of the adhesion process in the iron-iron system and the effects of carbon concentration on this system could prove to be valuable in relating the adhesion mechanism to that of the friction mechanism. Since the latter problem could immediately serve a dual purpose, the silver-halide-silver system study was set aside in favor of the iron-iron investigation.

The preliminary data from the ultra-high purity iron-iron couples has already proven most interesting, in that a relatively strong degree of adhesion was observed <u>without</u> the necessary argon ion cleaning demonstrated in previous studies. Since it is quite unlikely that the surfaces are atomically clean without this cleaning step, cf. Pignoco (1), there is evidently some impurity on the iron surfaces which acts as an adhesive agent other than the presence of free metallic surfaces. Such has been suspected in earlier studies on certain other systems; however, absolute proof was never achieved since the particular contaminant was never identified. More extensive investigations of iron-iron contaminated with varying degrees of carbon and/or oxygen, will provide more information on this peculiar behavior.

The technique for taking data as described in the two recent publications (2,3) from this laboratory, involved the addition, or removal, of a normal load to a torsion beam in ultra-high vacuum by increasing, or decreasing, the current to a solenoid which, in turn, acted magnetically on a iron slug attached to one end of the beam. This process was always accomplished in steps and the measurement of the contact resistance was made after each step. Such a technique was very slow, and often produced unnecessary data point scatter (load vs resistance) due to time variation between steps. Furthermore, the process never permitted a careful examination of the fine structure, particularly at the fracture point, of the load versus contact resistance curve.

During the last period, an apparatus was assembled such that the load could be automatically applied to some preselected peak load and then the load removed automatically to the fracture point. The output of the Sanborn (312) strain gauge monitor was then used as the input to a Brown Electronik Recorder. Since the contact resistance of the system under investigation is measured in a Kelvin Bridge circuit at a particular null point as detected on a nanovoltmeter, the only way a variation in contact resistance could be detected during a load varying cycle and still retain the bridge sensitivity, is to measure the variation from null, but immediately adjacent to the null point as the load, i.e. contact resistance, is changing. For example, the minimum resistance during a cycle is that at peak load and may be measured in the normal manner as described previously (2,3). Variations from this value extend to an open circuit and those of most pertinent interest lie within a few tenths of an ohm greater than this value. By calibration of the deflection of the nanovoltmeter null detector in 0.01 ohms per deflection unit from the null point and the utilization of the nanovoltmeter output as an input into a Brown Electronik Recorder, a complete history of the variation of contact resistance make-to-break can be recorded while the load is varied continuously through the preselected peak value to fracture. The apparatus has been fully tested, standardized, and is currently operational. The most desirable configuration, an x-y recording, with the x-function as the load (strain gauge output) and the y-function as the contact resistance, will be utilized when a recorder of this type is made available.

The preliminary data from this apparatus indicates that the contact resistance is a smooth function of load under conditions of surface contamination, irrespective of the nature of the loading cycle. This was observed as the contaminated iron samples were loaded to a peak load, partially unloaded, then loaded, etc. The contact resistance followed the loading and unloading in a respective manner. Under these conditions, the smallest detectable resistance change lies below 2.0×10^{-5} ohms at a contact resistance of about 0.05 ohm. There is little doubt that with the availability of this new tool a far better understanding of the relationship of contact area to adhesion, and, in turn, the mechanism of adhesion will be attained.

1) A.J. Pignocco and G.E. Pellissier, J. Electrochem. Soc., 112, 1188 (1965).

2) K.I. Johnson and D.V. Keller, Jr., J. Appl. Phys., 38, 1896 (1967).

3) K.I. Johnson and D.V. Keller, Jr., J. Vac. Sci. and Tech., 4, 115 (1967).